TITLE OF THE INVENTION

A MEDICINE, DRINK, FOOD AND FEED HAVING AN ACTION OF STRENGTHENING BONE

FIELD OF THE INVENTION

The present invention relates to a medicine, drink, food and feed having an action of strengthening bone. The medicine, drink, food or feed combined with collagen, fraction containing collagen, and/or degradation product that has effects of promoting bone formation, strengthening bone,preventing and treating bone metabolic diseases such as osteoporosis, bone fracture, bone pain and so on.

BACKGROUND OF THE INVENTION

Accompanying with the prolongation of human life span, the incidence of metabolic bone diseases such as osteoporosis,bone fracture,bone pain etc., recently increased. In bone tissue, bone formation and bone resorption are always occurring. While the balance of bone formation and bone resorption is kept in one's youth, bone resorption exceeds bone formation due to various causes as one's age increases (uncoupling). And when bone resorption prolongs for a long duration, bone tissue becomes fragile, which causes metabolic bone diseases such as osteoporosis, bone fracture, bone pain, etc., are expected to be prevented.

As conventional methods of preventing or treating metabolic bone diseases by inhibiting uncoupling, (1) calcium supplemented

diets, (2) light exercise, (3) sunbathing, (4) medicinal therapy, etc., are exemplified. As for calcium supplemented diets, calcium salts such as calcium carbonate, calcium phosphate, etc., and naturally occurring calcium-containing preparation, such as bovine bone powder, egg shell, fish bone powder, etc. are used. They are, however, not necessarily good enough for oral intake. As light exercises, jogging or walking may be recommended. However, they are troublesome to a person who becomes weak and quite difficult to an immobilized aged person. Sunbathing is believed to be good for supplement of active form of vitamin D_3 but is not sufficient. As medicinal therapy, 1 α-hydroxyvitamin D_3 and/or calcitonin may be used and they are known to be effective for treating osteoporosis. However, they are medicines themselves and can not be used as food sources.

On the other hand, collagen is known as a main protein component composing animal connective tissue and occupies nearly 30 % of total protein in mammalian, especially, human whole body. This collagen is a protein of cellular matrix and can be defined to be a substance having α-chain which is a helical portion consisting of 3 polypeptide chains and forming a multi-molecular complex. Further, collagen forms intercellular matrix with glycoproteins, such as proteoglycan, fibronectin, laminin etc., and is an essential component for exhibiting its function as assembled tissue of cells in multi-cellular biological organism.

The present inventors have investigated to find out a substance having action of strengthening bone which is useful for food sources. Eventually, we found out that a fraction containing

collagen such as skin protein fraction or bone protein fraction has an effect of promoting proliferation of osteoblast. Further, the present inventors found that degradation products of the fraction containing collagen also have an effect of promoting proliferation of osteoblast and accomplished the present invention.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a medicine, drink, food and feed having an action of strengthening bone. More specifically, the present invention is to provide a medicine, drink, food and feed having an action of strengthening bone combined with collagen, fraction containing collagen and/or degradation product thereof.

Another object of the present invention is to provide a medicine, drink, food and feed combined with collagen, fraction containing collagen or degradation product thereof which is combined with calcium and vitamins.

As a fraction containing collagen used in the present invention, skin protein fraction, bone protein fraction, lyophilization product of pulverized and skim corium layer, lyophilization product of pulverized and decalcified bone, and fraction which is produced by treating skin protein fraction or bone protein fraction with acid or alkiline can be exemplified. Further, degradation product which is produced by hydrolysis with a proteolytic enzyme and has a molecular weight of 2-150 kDa can be used.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 represents an action of promoting collagen synthesis in osteoblast by a fraction containing collagen or degradation product thereof obtained in test example 2.

Figure 2 represents breaking force of rat femur administered orally with fraction containing collagen or degradation product thereof obtained in test example 3.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS

In the present invention, collagen, a fraction containing fraction and/or degradation product thereof can be combined with a medicine, drink, food or feed for having an action of strengthening bone. This fraction containing collagen is a protein fraction obtained from skin or bone. For example, when it is prepared from skin, skin can be depilated and corium layer was cut off. The tissue can be cut into pieces with high-speed cutter, defatted with organic solvent and lyophilized to give a fraction containing collagen. And when it is prepared from bone, bone can be decalcified with acid etc., pulverized with a high-speed cutter, decalcified, again, with acid etc., and lyophilized to give a fraction containing collagen. Collagen can be more purified by treating skin protein fraction or bone protein fraction containing collagen with acid or alkaline. Treatment with acid or alkaline can be carried out by soaking these fractions in a 5-30 % of liquid solution of acid, such as hydrochloric acid or nitric acid, or alkaline, such as sodium hydroxide or potassium hydroxide, at 20-50°C for 0.5-3 hours. After soaking, these fractions

should be sufficiently washed with water. Hot water extraction of these fractions can be carried out by treating them with 70-80°C hot water.

Further, these fractions containing collagen can be hydrolyzed by a proteolytic enzyme, such as pepsin, trypsin, chymotrypsin, etc., whose solubility can be enhanced and used. Hydrolysis by a proteolytic enzyme can be carried out by pulverizing fractions described before, suspending them in water, adding about 1 % of proteolytic enzyme thereto and keeping it at 37°C for 0.5-6 hours. After hydrolysis, the reaction mixture was heated to deactivate proteolytic enzyme and ultrafiltrated, followed by collection of filtrate. Hydrolysis can be preferably carried out so that the molecular weight of degradation product will be 2-200 kDa.

In addition, calcium or vitamins can be combined with these fractions containing collagen. As a calcium source, calcium chloride, calcium carbonate, calcium lactate, egg shell or milk-derived calcium can be used. As combination rate of calcium with fraction containing collagen, 0.5-5.0 weight parts of said fraction will be preferable to 1 weight part of calcium. As vitamins, any vitamin can be used and vitamin D_3 or substance containing vitamin D_3 can be more preferably used. As raw material containing substantial amount of collagen, fresh skin or bone of cattle, pig, chicken, sheep and horse can be exemplified.

In the present invention, collagen, fraction containing collagen and/or degradation product thereof can be combined with a medicine, such as tablet or powder, and with a drink or food,

such as milk, yogurt, ice cream, milk drink, coffee drink, juice, jelly, noodle, cracker, bread or sausage, for endowing an action of strengthening bone. Further, in the same manner, these fractions or degradation product can be combined with a feed for endowing an action of strengthening bone. In addition, calcium agent with good absorptivity, such as calcium chloride, calcium carbonate, calcium lactate, egg shell or milk-derived calcium,etc., or vitamin D can be combined so that the action of strengthening bone thereof will be enhanced.

In the present invention, since oral administration of 10-2,500 mg of collagen, fraction containing collagen and/or degradation product thereof per day in an adult can exhibit an action of strengthening bone, collagen, fraction containing collagen, and/or degradation product thereof can be combined with a medicine drink or food by considering the above effective amount. Acute toxicity of fractions containing collagen, such as skin protein fraction or bone protein fraction was not observed in rat.

Since a medicine, drink, food or feed combined with collagen, fraction containing collagen and/or degradation product thereof has an action of strengthening bone, oral administration of these will be useful for prevention and/or improvement of bone metabolic diseases such as osteoporosis etc..

In addition, strengthening bone of livestock or poultry can be also carried out by combining collagen, fraction containing collagen and/or degradation product thereof with feed.

Preparation of fractions containing collagen and degrada-

tion products thereof, and an action of strengthening bone will be described by exemplifying reference examples and test examples as below. Further, the present invention will be described by exemplifying examples. However, these examples will not limit the scope of the present invention.

Reference example 1

Porcine skin (10 kg) was depilated and corium layer was taken, minced into pieces with a high-speed cutter, defatted with a solvent of hexane:ethanol (5:1) and lyophilized to yield 1,354 g of skin protein fraction (fraction A) containing collagen. This fraction contained 85 % of protein and the molecular weight distribution thereof was 50-200 kDa. The amount of protein was determined according to Lowry method (Lowry O.H., et al. (1951) J. Biol. Chem., 193, 265-275). Molecular weight distribution was determined by SDS polyacrylamide electrophoresis. The amount of protein and molecular weight distribution described below were also determined by the same method as the above.

Reference example 2

The skin protein fraction (1,000 g) containing collagen obtained in reference example 1 was suspended in water so that its concentration would be 5 %, followed by soaking it in an liquid solution of hydrochloric acid so that its concentration would be 10 % and washed sufficiently with water. Then, it was again suspended in water so that its concentration would be 10 % and heated at 90°C for 30 min., followed by lyophilization to

yield 620 g of skin protein fraction (fraction B) containing collagen. This fraction contained 93 % of protein and the molecular weight distribution thereof was 50-200 kDa.

Reference example 3

The skin protein fraction (300 g) containing collagen obtained in reference example 2 was suspended so that its concentration would be 5 % and 1 % pancreatin (Sigma) was added thereto, which was kept at 37°C for 2 hours and, then, heated at 80°C for 10 min. to deactivate pancreatin, followed by lyophilization to yield 280 g of degradation product of skin protein fraction (fraction C) containing collagen. This fraction contained 95 % of protein and the molecular weight distribution was 2-50 kDa.

Reference example 4

Bovine bone powder (10 kg) was suspended in water so that its concentration would be 10 % and decalcified with treatment of hydrochloric acid so that its concentration would be 10 %. Then, it was minced into pieces with a high-speed chopper and decalcified by soaking it in an liquid solution of hydrochloric acid so that its concentration would be 10 %. Further, it was sufficiently washed with water, lyophilized and pulverized with a pulverizer to yield 2,210 g of bone protein fraction (fraction D) This fraction contained 89 % of protein and the molecular weight distribution thereof was 50-150 kDa.

Reference example 5

The bone protein fraction (1,000 g) containing collagen obtained in reference example 4 was suspended in water so that its concentration would be 5 %, followed by soaking it in sodium hydroxide solution so that its concentration would be 10 % and washed sufficiently with water to yield 540 g of bone protein fraction (fraction E) containing collagen. This fraction contained 92 % of protein and the molecular weight distribution was 50-150 kDa.

Reference example 6

The bone protein fraction (300 g) containing collagen obtained in reference example 5 was suspended so that its concentration would be 5% and 1 % pancreatin (Sigma) was added thereto, which was kept at 37°C for 2 hours and, then, heated at 80°C for 10 min. to deactivate pancreatin, followed by lyophilization to yield 290 g of degradation product of bone protein fraction (fraction F) containing collagen. This fraction contained 95 % of protein and the molecular weight distribution was 3-70 kDa.

Test example 1

Fractions A-F obtained in reference examples were investigated with respect to an action of inhibiting bone resorption. Long bone were extirpated from 10-20 days old ICR mice and the whole bone marrow cells comprising osteoclast were obtained by depriving soft tissue from the bones and mincing the bones in α-modified minimum essential medium (α-MEM) containing 5 % bovine fetal serum mechanically. About 2 x 10^6 of these cells in α-MEM

containing 5% bovine fetal serum were placed on a piece of dentinum. Two hours after then, a test sample in α-MEM containing 5 % bovine fetal serum was added so that the final concentration would be 10 μg/ml, which was cultured for 5 days and bone resorptive activity of osteoclast was investigated. Analysis of bone resorption was carried out by depriving cells from a piece of dentinum after cultivation thereof, staining them with Hematoxylin dye and counting the number of bone resorptive pit by morphometrical analysis with PIALA-555. As control, culture without any addition was used and bone resorptive activity of each case was calculated by defining 100 % as that in the case of non-added group. The results were represented in table 1.

Comparing with bone resorptive activity of non-added group, any group with addition of fraction A-F which was skin protein fraction or bone protein fraction and contained collagen obtained in reference examples was found to have an action of inhibiting bone resorption.

Table 1

	Bone resorptive activity
Control	100 (%)
Fraction A	86
Fraction B	84
Fraction C	85
Fraction D	81

Fraction E	75
Fraction F	84

Test example 2

Action of promoting collagen synthesis of fractions A-F obtained in reference examples was studied. That is, 2×10^4 cells/ml of osteoblastic cell line MC3T3-E1 in α-MEM containing 10 % bovine fetal serum (Flow Laboratories) was inoculated in each well of 96-well plate and cultured at 37°C for 24 hours in the presence of 5 % CO_2. Then, the medium was changed into α-MEM, which did not contain bovine fetal serum, to which fractions A-F obtained in reference examples was added so that the final concentration thereof would be 10 μg/ml and cultured at 37°C for 3 days. After then, the amount of synthesized collagen was measured by determining hydroxyproline. Determination of hydroxyproline was carried out by hydrolyzing suspension of punctured cultured cells with 6N hydrochloric acid and using p-dimethylaminobenzaldehyde according to Woessner's method (Woessner, J.F., Arch. Biochem. Biophys., vol.93, pp440-447, 1961) and the results were represented in figure 1. The amount of hydroxyproline in culture with addition of fractions A-F obtained in reference examples which were skin protein fraction or bone protein fraction and contained collagen was higher than that in culture without addition of those fractions, which suggested stimulation of collagen synthesis in osteoblast by the fractions.

Test example 3

Action of strengthening bone of fraction B, C, E and F were studied in animal experiments. Osteoporotic model rats were made by ovarectomy of 6-weeks-old female SD rats after raising for 1 week and feeding with low calcium diet for 2 months and used in animal experiments. These rats were divided into 5 groups consisting of 7 rats, that is, control group, 1.5 % fraction B administered group (I group), 1.5 % fraction C administered group (II group), 1.5 % fraction E administered group (III group) and 1.5 % fraction F administered group (IV group) and fed with test diets consisting of components represented in table 2 for 1 month. In addition, 7 sham rats were also made by sham operation wherein ovary was not extirpated and used in the same experiments. As calcium source of mineral mixture in table 2, calcium carbonate was used.

Table 2

	Control g.*	Sham g.*	I group	II group	III group	IV group
Sucrose	49.3	49.3	49.3	49.3	49.3	49.3
						(g/100g)
Casein	20.0	20.0	18.5	18.5	18.5	18.5
Corn starch	15.0	15.0	15.0	15.0	15.0	15.0
Cellulose	5.0	5.0	5.0	5.0	5.0	5.0
Corn oil	5.0	5.0	5.0	5.0	5.0	5.0
Vitamin mix.**	1.2	1.2	1.2	1.2	1.2	1.2

(including choline)						
Mineral mix.**	4.5	4.5	4.5	4.5	4.5	4.5
Fraction B			1.5			
Fraction C				1.5		
Fraction E					1.5	
Fraction F						1.5

* g.:group, ** mix.:mixture

In addition, test diets consisting of components represented in table 3 were also fed in another experimental groups, that is, (1.5 % fraction B + milk-derived calcium + vitamin D_3 400 IU)administered group(V group), (1.5 % fraction E + milk-derived calcium + vitamin D_3 400 IU) administered group (VI group), 0.2 % fraction B administered group, 2.0 % fraction B administered group. As calcium source in mineral mixture, calcium carbonate was used in VII group and VIII group and milk-derived calcium (Japanese published unexamined patent application No. 6-125740) was used in V group and VI group. In test diets in table 2 and table 3, the amount of casein was adjusted so that nitrogen content in the all test diets would be the same. And in 100 g of test diet, 400 mg of calcium and 300 mg of phosphate were contained.

Table 3

	V group	VI group	VII group	VIII group
Sucrose	49.3	49.3	49.3	49.3 (g/100g)
Casein	18.5	18.5	19.8	18.0
Corn starch	15.0	15.0	15.0	15.0
Cellulose	5.0	5.0	5.0	5.0
Corn oil	5.0	5.0	5.0	5.0
Vitamin mix.* (including choline)	1.2	1.2	1.2	1.2
Mineral mix.*	4.5	4.5	4.5	4.5
Fraction B	1.5		0.2	2.0
Fraction E		1.5		

* mix.:mixture

After 1 month administration, femurs of rats in each test group were taken and breaking force thereof was determined by a breaking force analyzer (Rheometer, Max RX-1600, I-thechno), whose results were represented in figure 2.

As represented in this figure, fractions B, C, E and F which were skin protein fractions or bone protein fractions and comprised collagen were found to have significant action of strengthening bone. Action of bone strengthening thereof were found to be augmented by combination with milk-derived calcium having good absorptivity and vitamin D_3. Further, since there was significant difference with respect to bone strength when the ra-

tio of calcium to collagen was 1.0:0.5-5.0, combination of 0.5-5.0 weight part of fraction containing collagen with 1 weight part of calcium was found to be effective.

The present invention will be explained by exemplifying examples.

Example 1

A tablet having action of strengthening bone was prepared by mixing raw materials represented in table 4 and formulating it under pressure.

Table 4

Crystalline glucose hydrate	73.5 (weight %)
Fraction F in reference example 6	20.0
Calcium	5.0
Sugar ester	1.0
Flavor	0.5

Example 2

A drink having action of strengthening bone was prepared by mixing raw materials represented in table 5, packing it in a container and sterilizing it by heating.

Table 5

Mixed isomerized saccharide	15.0 (weight %)
Fruit juice	10.0
Citric acid	0.5
Fraction A in reference example 1	0.5
Flavor	0.1
Calcium	0.1
Water	73.8

Example 3

A cracker having action of strengthening bone was prepared by mixing raw materials represented in table 6, making dough, formulating and baking it.

Table 6

Wheat powder	50.0 (weight %)
Sugar	20.0
Sodium chloride	0.5
Margarine	12.5
Egg	12.1
Water	2.5
Sodium bicarbonate	0.1
Ammonium bicarbonate	0.2
Calcium carbonate	0.5
Fraction B in reference example	1.2

Example 4

A jelly having action of strengthening bone was prepared by mixing raw materials represented in table 7, packing it in container and sterilizing it by heating.

Table 7

Fructose	20.0 (weight %)
Granulated sugar	15.0
Miller jelly	5.0
Agar	1.0
Fraction A in reference example 1	0.5
Flavor	0.1
Calcium	0.1
Water	58.3

Example 5

A processed cheese having action of strengthening bone was prepared by mixing raw materials represented in table 8 and emulsifying it at 85°C.

Table 8

Gouda cheese	43.0 (weight %)
Cheddar cheese	43.0

Sodium citrate	2.0
Fraction B in reference example 2	0.5
Milk-derived calcium	1.0
Water	10.5

Example 6

After sterilizing 12 weight % reducing skim milk at 90°C for 20 min., Lactobacillus acidophilus and Streptococcus thermophilus were inoculated to give 2 kinds of starter culture, which were mixed in the same amount. A yogurt having action of strengthening bone was prepared by mixing raw materials represented in table 9 and fermenting it.

Table 9

Yogurt mix	96.5 (weight %)
Starter culture	3.0
Fraction C in reference example 3	0.5

Example 7

A powder milk for infant having action of strengthening bone was prepared by mixing raw materials represented in table 10.

Table 10

Skim milk	75.5 (weight %)
Whey protein concentrate	2.4
Lactose	13.5
Mineral mix	0.3
Water soluble vitamin mix	0.3
Fat containing fat-soluble vitamin	7.5
Fraction F in reference example 6	0.5

Example 8

A feed for dog having action of strengthening bone was prepared by mixing raw materials represented in table 11.

Table 11

Soy bean cake	12.0
Skim milk powder	14.0
Soy bean oil	4.0
Corn oil	2.0
Palm oil	28.0
Corn starch	15.0
Wheat powder	8.0
Wheat bran	2.0
Vitamin mix	9.0
Mineral mix	2.0
Cellulose	3.0
Fraction A in reference example 1	1.0